

Measurement & Verification (M&V)

*What you don't measure,
you can't manage.*



U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy

M&V is a factor throughout the ESPC process

• Acquisition Planning	Phase 1
• ESCO Selection	2
• Preliminary Assessment	2
• Notice of Intent to Award	2
• Request for Proposal	3
• Investment-Grade Audit	3
• Proposal	3
• Negotiations and Task Order Award	3
• Final Design and Construction	4
• Project Acceptance	4
• Post-Acceptance Performance Period	5

What is M&V, and why do you need it?

- M&V refers to any activities aimed at determining whether the savings guarantee is being met
 - The guarantee and annual M&V are legally and contractually required
- When M&V is done well, it will:
 - Reduce uncertainty of the savings estimates to a reasonable level
 - Allocate risks appropriately
 - Potentially identify operations & maintenance issues



Basic M&V Concepts

- M&V methods should balance savings assurance against added cost
- The degree of M&V should be proportional to
 - 1) the ECM's savings; and
 - 2) the ECM's performance risk
- Good M&V plans require ESCOs to measure the key performance parameters of ECMs
- If the M&V plan is weak, the guarantee may be met only on paper



FEMP Guidance on M&V

- FEMP M&V Guidelines v. 4.0
 - M&V specifically for federal energy projects
 - Application of the International Performance Measurement and Verification Protocol (IPMVP)
- The Guidelines and the following M&V resources are available on FEMP ESPC Resources pages at <http://energy.gov/eere/femp/articles/resources-implementing-energy-savings-performance-contracts> :
 - Introduction to M&V for FEMP ESPC Projects
 - Guidance on government witnessing of M&V
 - Guidance on reviewing M&V plans and reports



M&V in the ESPC Process

(more on this in Phases 4 & 5)

Baselines	<ul style="list-style-type: none"> • Defined in IGA and Proposal
M&V Plan	<ul style="list-style-type: none"> • Developed as part of Proposal
Post-Installation M&V Report	<ul style="list-style-type: none"> • Verification of ECMs' ability to perform
Annual M&V	<ul style="list-style-type: none"> • Activities per M&V Plan • Findings documented in M&V reports



Baselines

- Typically proposed for each ECM by ESCO as part of investment-grade audit; agency reviews/approves
- Baselines are compared to post-installation energy use to determine savings
- Once project is installed, it's difficult or impossible to revisit baselines, so properly defining them is important
- Baselines may vary with changes in weather (or other factors, potentially)
 - e.g., gas usage = $2500 \text{ MMBtu} + 46 \times (\text{Heating Degree Days})$



Savings Guarantee

- Savings must exceed payments
 - This is cardinal rule of federal ESPC
 - DOE has interpreted this to mean that savings must exceed payments in each year
- Savings that may be used to pay the ESCO:
 - Energy and water cost savings
 - Energy/water-related cost savings



Energy and Water Cost Savings

- Reductions in system use
- Efficiency improvements
- Reductions in peak demand
- Reductions in energy rates
- Shifting time of use to lower-cost periods
- Switching to less expensive fuels
- Self-generation (including cogeneration/CHP)
- Reduced water and sewer use
- Reduced sewer charges (e.g., due to irrigation)



Energy/Water-Related Cost Savings

- Most commonly reduced O&M expenses
 - Parts and repair costs
 - Equipment replacement costs
 - O&M contracts and other labor
- Cost savings must be real
 - If labor savings are claimed, agency must demonstrate contract or staff reductions
 - Reducing tasks of existing staff does not count



Other Sources of Savings (and thus payments)

One-time energy-related savings

- Cost avoidance provided by the project
 - Example: Including chiller replacement funds in project where funds were planned to be paid out of repair & replacement budget in early year of project
- Construction period energy savings
 - Savings accrued from ECMs that are installed and performing in advance of project acceptance
- More info on acceptable sources of savings:
 - Practical Guide to Savings and Payments in Federal ESPC Projects, in “Resources” section of ESPC Web site

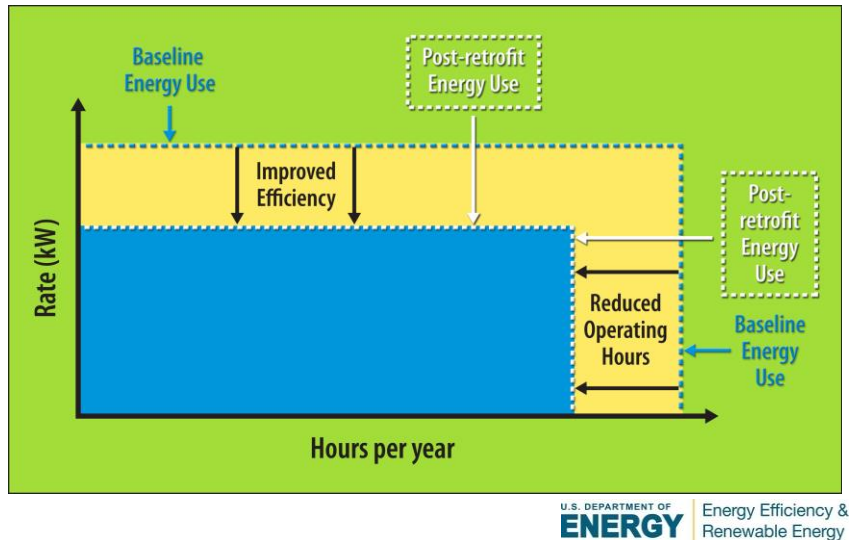


Calculating Savings

- The two components of energy use
 - Rate of energy use (e.g., wattage) – or Performance
 - Usage (hours of use)
- Energy use is the product of the two
 - Example: $4 \text{ kW} \times 2 \text{ hours} = 8 \text{ kWh}$
- Reducing the rate of energy use or the usage (hours) reduces the total energy use



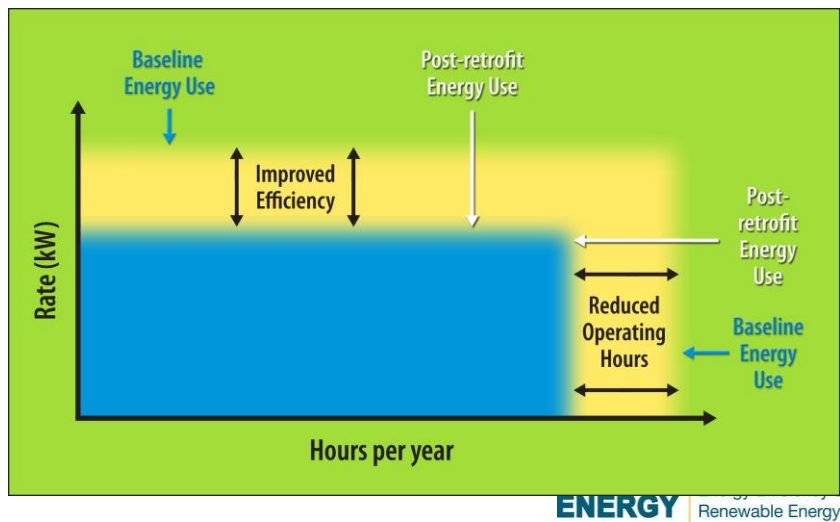
Achieving Energy Savings



Savings Uncertainty

- We can't measure savings directly
 - Because it's the absence of something – i.e., it's energy use that's not there any more!
- We measure energy use before and after the ECM – the savings is the difference (roughly)
- We usually don't know the exact energy use before and after
 - there is almost always some uncertainty in each
- And even when we do, we can't know for sure what's responsible for all the change

Achieving Energy Savings: The Real Picture

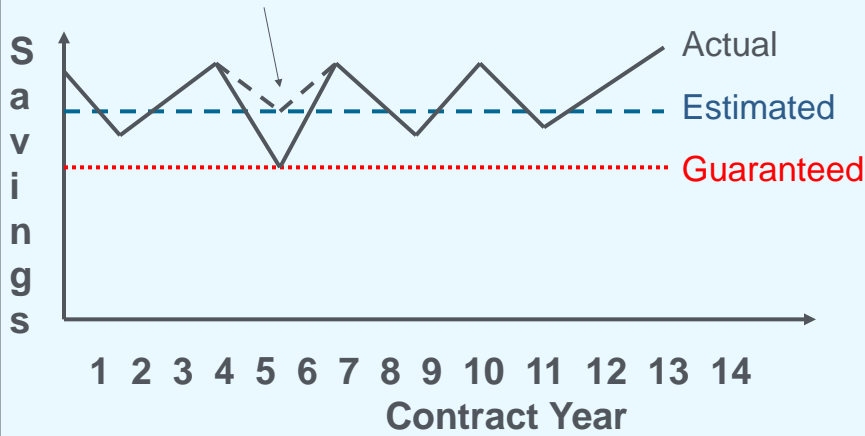


Uncertainty can be reduced, but never eliminated

- Claimed savings are always estimates because savings cannot be measured directly
- Uncertainty is introduced through:
 - Measurement and modeling error
 - Sampling error
 - Simplifying assumptions
 - Other changes at facility
- These factors are inherent in M&V

Using M&V to Manage Risk – Weather Example

Savings can be normalized to account for mild or severe weather years.
Example: Mild summer in year 5 adjusted to average using TMY.



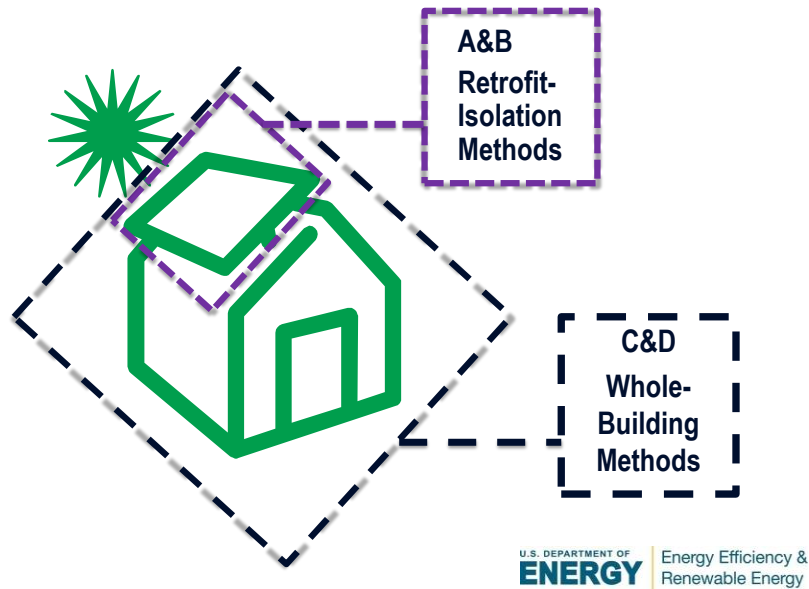
U.S. DEPARTMENT OF
ENERGY | Energy Efficiency & Renewable Energy

M&V Method Options: A, B, C, and D

- Each ECM is assigned an M&V option
- Measurements differ by:
 - Level – individual system vs. whole building
 - Duration – spot, short-term, periodic, continual
 - Whether key values are held constant without performance period measurement
 - Example: Hours of lighting operation may be determined in IGA and then fixed for purposes of savings calculation
 - Expense
 - Up-front – averages about 3% of project investment
 - Annual – averages about 3% of annual savings
 - More complex, interactive ECMs justify more M&V effort

U.S. DEPARTMENT OF
ENERGY | Energy Efficiency & Renewable Energy

Options A/B vs. Options C/D



FEMP and IPMVP M&V Options

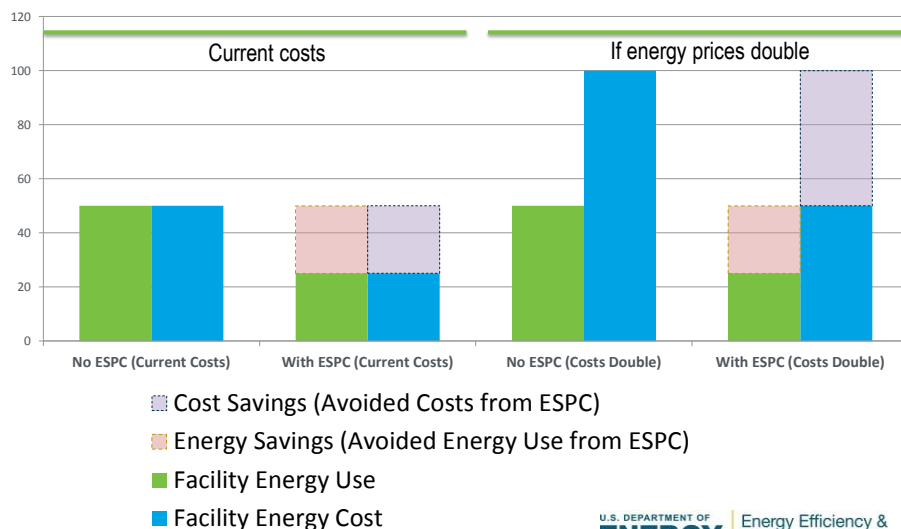
M&V Option	How savings are calculated
Option A: “Retrofit Isolation, Key Parameter” – Based on measurement of <i>key</i> parameter, either equipment performance or operational factors (usually equipment performance)	Engineering calculations using measured and estimated data
Option B: “Retrofit Isolation, All Parameters” – Based on measurements (usually periodic or continuous) taken of <i>all</i> relevant parameters; often entails long-term metering.	Engineering calculations using measured data
Option C: Based on <i>whole-building</i> or facility-level utility meter data adjusted for weather and/or other factors.	Analysis of utility meter data
Option D: Based on <i>computer simulation</i> of building or process; simulation is calibrated with measured data.	Comparing different models

Energy Prices and ESPC Savings

- When energy prices go up, savings appear to evaporate, because total utility costs go up
- What is the actual effect of per-unit energy price increases on ECMs' savings (cost avoidance)?
 - Yes, the bills may go up relative to prior levels, but ...
 - Key issue is what they would be without the ESPC
- ESPC can be seen as a hedge against higher energy prices



What if energy prices increase?



Best M&V Practices During Project Development

- Understand ESCO's perspective.
 - They're guaranteeing performance – is closer inspection (i.e., more M&V) in their interest?
- Recognize that goal is to reduce uncertainty in savings ... but that adding M&V adds cost.
 - Need to balance these two
 - More complex ECMs usually merit more M&V



Best M&V Practices During Project Development

- Make sure that ESCO-proposed baselines and fixed parameters for ECMs are sound
 - Because they are cornerstones of the savings calculation
- Stay involved throughout performance period
 - Review annual M&V reports, stay in touch with ESCO, etc.
 - Take advantage of FEMP's life-of-contract support



Review Questions

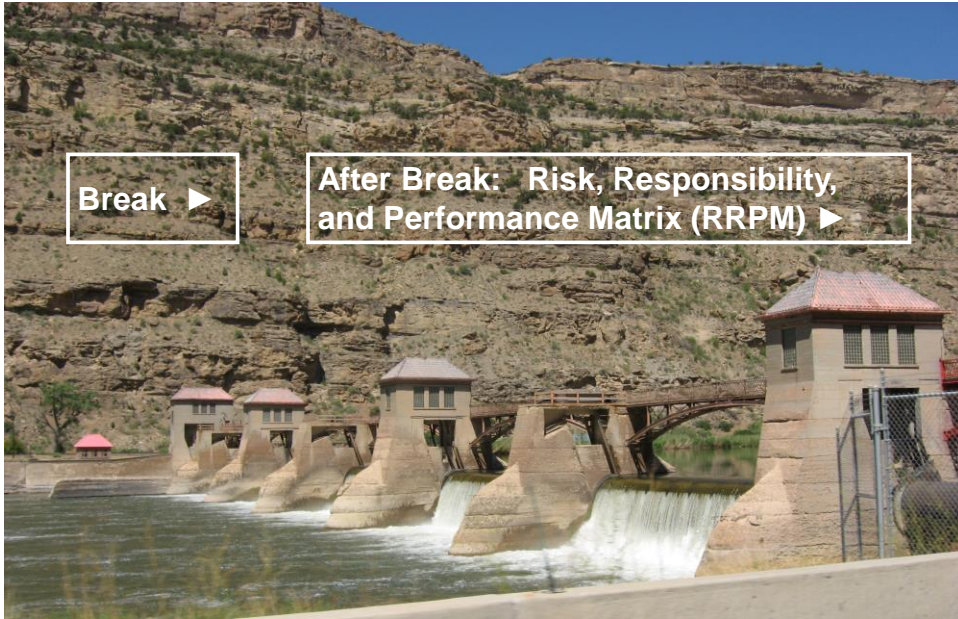
- Q1: Why is M&V required in ESPC?
- A: It's required by law; to verify that guaranteed savings are delivered and ensure that savings persist.
- Q2: The degree/cost/rigor of M&V should be proportional to the ECM's _____ and _____.
- A: savings and risk
- Q3: Identify one source of one-time energy-related cost savings.
- A: (1) Cost avoidance when ESPC includes something agency was planning to install itself;
(2) Implementation-period savings from ECMs installed and conditionally accepted early in construction



Review Questions

- Q4: We can't directly measure savings, but we can measure energy use, _____ and _____.
- A: before and after
- Q5: Name the two retrofit-isolation M&V options.
- A: Option A and Option B
- Q6: M&V can reduce – but never eliminate – _____.
- A: Risk or uncertainty





U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy